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CONTAGIOUS DISEASES: THEIR MODES OF TRANSMISSION[1]

By CHARLES CLYDE SUTTER, M.D.

Rochester, N. Y.

To properly combat and stamp out contagious and infectious diseases we must first know the exact cause of the disease and then we must discover the actual methods of transmission of the disease germs. Methods of prevention must be based upon this knowledge. A sign of progress along this line is shown by the frequent changes made in our health laws. Sanitary measures directed against infectious diseases must be modified, from time to time, to correspond with existing knowledge.

Our views concerning these matters are undergoing rapid changes, partly owing to the rapidly-accumulating knowledge of bacteria and other disease-producing organisms, and partly owing to direct observations on the manner in which infectious diseases are disseminated, and on the effect of certain preventive measures.

Our first idea of disease was that the germs of disease commonly grew in decaying organic matter, yet, at this time, contagion was recognized as a factor in the spread of disease, and isolation was insisted upon. With the discovery that bacteria and protozoa were the specific causes of disease and that they were distributed widely in dead organic matter, came the theory that the source of disease was outside of the body and chiefly in dead animal and vegetable matter. Later it appeared that the growth of disease germs outside of the body was not frequent enough to be an important factor in the production of disease. Animal parasites, which belong to the protozoa, can be cultivated only with difficulty, and even the cultivation of the more common bacteria is strictly limited, so that it is hardly possible to imagine their maintaining a saprophytic existence. The germs of typhoid fever, cholera, dysentery, and diphtheria may be conceived of as growing outside of the body, under natural conditions, but such growth must be exceedingly rare. Anthrax and tetanus bacilli and the pus-producing bacilli may develop in the soil, but there is no evidence that they commonly do so. There is not the slightest reason for supposing that tuberculosis, influenza, cerebrospinal meningitis, scarlet fever, small-pox, whooping cough, gonorrhoea, syphilis, yellow fever and sleeping sickness ever develop outside of the body. The cleansing of streets, alleys and back yards, of dwellings and stables, the regulation of offensive trades and the prevention of nuisances generally, then, have, except for one or two diseases, no direct relation to the general health, nor any value in the prevention of specific diseases. They do, however, aid in the extermination of insects and vermin which have been proven to carry the disease germs of certain diseases. Municipal cleanliness will tend to promote personal cleanliness, and real personal cleanliness is a very important factor in the prevention of contagion.

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The next theory, which was almost universally accepted until recently, was that the air was the chief medium for the transmission of fomites, containing disease germs. Health laws were then based on this view and most health officials insisted that contagious diseases could be stamped out if all persons so infected could be isolated.

With the abandonment of this theory, that disease is air-borne, we are forced to believe that the transmission of disease is through direct contact with the sick or healthy carriers of disease germs, or through the medium of certain insects, such as the mosquito, fly, tick, flea or bed-bug. There are many problems which investigators have not solved and there are many which must be interpreted scientifically before we shall be able to completely stamp out infectious or contagious diseases. To derive the most benefit we must study the problems from a practical standpoint, and note carefully the relative importance of the different sources of disease and the different methods of infection. Thus, it is of more importance to know that 99 per cent of typhoid bacilli die in water in one week than to know that a few may live many weeks. It is important to know that disease germs may be carried by the air and be recovered from articles in the sick room, but we must also know the amount of germs which we may expect to be thus carried and how often disease is traced to such a source. The finding of tubercle bacilli in the milk has given us much alarm, but since a serious effort has been made to measure the actual danger, the alarm has greatly diminished. The typhoid bacillus has been carried by the fly, but we are profoundly ignorant of the percentage of cases of typhoid fever so transmitted.

The relation of dust to disease is important. Dust itself may, by directly irritating the respiratory passages, open the door to tuberculosis and other infections of the air passages, such as common colds, influenza, and pneumonia. Street dust may contain pathogenic organisms such as tubercle bacillus, many varieties of cocci, the colon bacillus, *bacillus aerogenous capsulatus*, and possibly, under special conditions, tetanus, malignant edema, and occasionally other pathogenic microorganisms. Fortunately, most microörganisms, pathogenic for man, soon die when dried or when exposed to sunlight. Whatever danger, then, resides in the air, so far as living bacteria are concerned, is found rather in indoor air, and especially in the air of badly-ventilated, dusty, and crowded places. Here the danger may be either from the bacteria-laden dust or from droplet infection. While the air plays a minor rôle in the spread of the infections, bad air plays an important part in reducing vitality and predisposing to disease.

Tuberculosis has long been considered a primary inhalation disease because the lungs are most affected. This theory has been greatly overestimated. Very few bacteria, suspended in the air, actually reach the lungs, being caught on the moist mucous membranes of the upper air passages. Furthermore, tuberculosis of the lungs is usually located at the apex, which is not in the direct line in which bacteria or floating particles would be mechanically carried. During speaking, and especially during loud talking, coughing and sneezing, tiny droplets of saliva, containing live bacteria, are thrown from the mouth. Such droplets may be readily seen in the proper light. It has been shown by experiment that no bacilli were found as near as 6 inches during deep breathing, but after coughing they could be recovered from all parts of the room. It was not possible to infect animals with mouth spray over 25 cm. from the mouth but tubercle bacilli were collected on agar plates at the distance of a meter. No enumeration seems to have been made and difficulty of finding them suggests that they are not very numerous. Perhaps the air of the room is not always dangerous to breathe even if tubercle bacilli can be found in the settled dust. Danger would, of course, be increased if the soil be rendered susceptible by previous disease or by irritation of dust, etc. Tubercle bacilli, contained in the droplets sprayed from the mouth are fresh and virulent and may be conveyed indirectly through the food, fingers, eating utensils or other objects.

The diphtheria bacillus like the tubercle bacillus may be transmitted directly from one person to another, as by kissing, or exposure to droplets sprayed from the mouth in coughing, speaking or sneezing.

The most common method of transmission among children, perhaps, is by toys, slate pencils, food, fingers, handkerchiefs, or other objects that have been mouthed first by the infected child and then by the susceptible child.

Bacillus carriers play a large rôle in the spreading of typhoid fever and diphtheria. They are especially dangerous because they are usually not recognized and no precautions are observed. Their recognition and elimination will be a great factor in the prevention and dissemination of these diseases.

The frequency of the mouth's agency in the production of disease is almost altogether overlooked. The bacteria which are recognized as the active agents in the causation of many diseases are mostly received into the body through the mouth. Here is a central propagating place for many varieties of bacteria. An absolutely clean and otherwise healthy mouth and normal gastric digestion will prove a barrier to most of the pathogenic bacteria.

The recent discovery of the transmission of disease by insects gives us entirely new and most effective means of combating disease. The mosquito has been proven to be the method of transmission of malaria, yellow fever, filariasis and dengue. The tick has been the means of transmission of Texas fever, Rocky Mountain spotted fever, African tick fever and relapsing fever. Relapsing fever may also be transmitted by the bed-bug. Plague has been known to be transmitted by the flea. The most important of the insects and the one to which we are giving considerable attention at present is the fly. To it is given the credit of transmitting a long list of diseases, including sleeping sickness, pink eye, purulent ophthalmia of Egypt, typhoid fever, cholera, dysentery and possibly contagious ophthalmia, erysipelas, anthrax, glanders and other skin infections, small-pox and other exanthems. The most important recent addition to this list is that of poliomyelitis, which may be transmitted by the *stomoxys calcitrans* or stable fly (Rosenau).

The suppression of insects and household vermin is essentially a question of cleanliness. The most effective measures will be those which strike at their breeding places. Food must be so protected that insects, mice and rats cannot gain access to it. Cleanliness and incessant care must not only be exercised in the household itself but must also include the back yard and surroundings of the house. Old cans and broken bottles, rubbish, garbage, and general untidiness around the household afford breeding places, hiding places or food for vermin. Food should also be protected from contamination by the cat, dog or other animals of the house.

We are now better able than before to attribute to water and milk their proper share in the distribution of infection. From time immemorial water has been believed to be the bearer of disease, but it is only since the middle of the nineteenth century that the subject has been studied scientifically. While tuberculosis, diarrhoea, dysentery and cholera may be transmitted by water, polluted with sewage, typhoid is probably the only disease frequently transmitted in this manner.

Milk has been known to transmit typhoid fever, tuberculosis and occasionally scarlet fever and diphtheria. Milk is also considered by some to be an important factor in the production of infant diarrhoeas.

The question of the transmission of tuberculosis has resulted in much controversy. "It is now practically settled that the two types of bacilli—bovine and human—are distinct and quite permanent, and that they are reciprocally infective though not to the same degree (Chapin)."

Fruit and vegetables, such as celery, lettuce, and radishes, may be dangerous, if grown on land fertilized with night soil. This may account for an occasional case of typhoid fever, but there is no epidemiological evidence that they may transmit any of the so-called contagious diseases.

The danger of typhoid fever being transmitted by raw shell fish is not very great, but this danger should be eliminated entirely by prohibiting the sale of shell fish from polluted waters.

The diseases which it is alleged may be transmitted by flesh foods are those caused by animal parasites, of which trichinosis is the most important, diseased conditions by the colon group of bacilli, and tuberculosis.

The prevention of infection may be summed up in a word—cleanliness, not only of food, water and milk, but also cleanliness of person and environment. There must be physical and biological cleanliness.

Contact infection is the greatest factor in the dissemination of disease. The hands are the part of our bodies most frequently in contact with infected and unclean materials. Unless precautions are observed until they become a habit, this will lead to the conveying of disease germs to the mouth either directly or by the handling of food or anything we put in the mouth. The best advice that can be given is to keep the hands clean and keep the hands out of the mouth. We can rest assured that if people can be better taught to practice strict personal cleanliness, they will do more than anything else to prevent infectious diseases.

Persons with tuberculosis or other communicable disease should not be permitted in any department where meat, meat products or food of any kind are handled or prepared in any way. Garden truck must be grown in clean dirt and not in soil polluted with human excrement. Food must be guarded in transportation and purveyed in markets and shops protected from flies, rats, dust and unnecessary human contact.

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